CLAIMS

We claim:

1. A method of chemical-mechanical jet etching of patterned features in a semiconductor workpiece, by impinging a machining etchant fluid upon a surface of said workpiece, whereby material is removed from said surface of said workpiece at an etch rate of at least about 10 microns per minute, forming three-dimensional features thereon.

2. The method of Claim 1, wherein such workpiece comprises a material selected from the group consisting of a silicon wafer or gallium arsenide or other semiconductor substrate, silicon-on-insulator ("SOI"), SiO_2, glass, quartz, pyrex, ceramic, or glass bonded to a substrate, conductor, or insulator.

3. The method of Claim 1, wherein said workpiece is first masked with a patterned protective mask, such that material is selectively removed from said surface only in areas which are not covered by said mask.

4. The method of Claim 1 or Claim 3, wherein said machining etchant comprises a slurry of solid particulate material in a liquid.

5. The method of Claim 4, wherein said slurry is a suspension or dispersion.

6. The method of Claim 1 or Claim 3, wherein said machining etchant comprises solid particulate material in a carrier gas stream.

7. The method of Claim 4, wherein said liquid is a chemical etchant for the material of said workpiece.

8. The method of Claim 4, wherein said liquid is not a chemical etchant for said workpiece material, but acts as a solvent for a compound which is a chemical etchant for the material of said workpiece..

9. The method of Claim 7, wherein said chemical etchant is a compound selected from the group consisting of KOH, NaOH, HF, HNA(an aqueous solution of about 7 wt % HF, about 30 wt.% HNO_3, and about 10 wt.% CH_3COOH),TMAH (Tetramethyl Ammonium Hydroxide), EDP (Ethylene Diamine Pyrochatechol), amine gallates.

10. The method of Claim 1or Claim 3, wherein said machining etchant is delivered to a surface of said workpiece by one or more nozzles.

11. The method of Claim 4, wherein said machining etchant is delivered to a surface of said workpiece by one or more nozzles.

12. The method of Claim 6, wherein said machining etchant is delivered to a surface of said workpiece by one or more nozzles.

13. The method of Claim10, wherein one or more of such nozzles is a dual nozzle, having a central orifice surrounded by an annular orifice, through which orifices jets of either a single type of machining etchant or of two different types of machining etchants can be delivered to the workpiece surface.

14. The method of Claim 13, wherein a selection of pressures and viscosities of a first machining etchant supplied to the central orifice and a second machining

etchant supplied to the annular orifice of said at least one dual nozzle, results in distinct inner and outer jets, whereby the outer jet confines the inner jet to a narrower dimension than would occur in the absence of the outer jet.

15. The method of Claim 10, wherein said machining etchant is delivered to the surface of said workpiece as said nozzle or nozzles and such workpiece are rotated, translated, or rastered relative to one other.

16. The method of Claim 1 or 3, wherein said machining etchant is delivered to the surface of said workpiece as said workpiece is rotated, translated, or rastered past said nozzle or nozzles, which are stationary.

17. The method of Claim 1 or 3, wherein said machining etchant is delivered to the surface of said workpiece as said nozzle or nozzles are rotated, translated, or rastered past said workpiece, which is stationary.

18. A method of chemical-mechanical jet etching a semiconductor workpiece, by impinging a machining etchant fluid upon a surface of said workpiece, whereby workpiece material is removed uniformly from said surface of said workpiece, whereby the thickness of said workpiece is uniformly decreased from its original value to a desired smaller thickness, at a minimum etch rate of at least about 10 microns per minute.

19. The method of Claim 18, wherein such workpiece comprises a material selected from the group consisting of a silicon wafer or gallium arsenide or other semiconductor substrate, silicon-on-insulator ("SOI"), SiO_2, glass, quartz, pyrex, ceramic, or glass bonded to a substrate, conductor, or insulator.

20. The method of Claim 18, wherein said machining etchant comprises a slurry of solid particulate material in a liquid.

21. The method of Claim 20, wherein said liquid is a chemical etchant for said workpiece material.

22. The method of Claim 20, wherein said liquid is not a chemical etchant for said workpiece material, but acts as a solvent for a compound which is a chemical etchant for said workpiece material.

23. The method of Claim 20, wherein said dissolved chemical etchant is a compound selected from the group consisting of KOH, NaOH, HF, HNH, TMAH (Tetramethyl Ammonium Hydroxide), EDP (Ethylene Diamine Pyrochatechol), amine gallates. .

24. The method of Claim 18, wherein said machining etchant comprises solid particulate material in a carrier gas stream..

25. The method of any of Claims 18, 20, or 24, wherein said machining etchant is delivered to the surface of said workpiece by one or more nozzles.

26. The method Claim 20, wherein at least one of such nozzles is a dual nozzle, having a central orifice surrounded by an annular orifice, through which orifices either a single type of machining etchant or two different types of machining etchants can be delivered to the workpiece surface.

27. The method of any of Claims 18, 20, or 24, wherein said machining etchant is delivered to the surface of said workpiece as said nozzle or nozzles and such workpiece are rotated, translated, or rastered relative to one other.

28. An apparatus which performs jet etching on semiconductor workpieces, said apparatus comprising:

a) at least one ejector device which projects a machining etchant fluid onto a surface of a semiconductor workpiece, whereby material is etched from said workpiece surface, wherein said ejector device is oriented with respect to said workpiece surface;

b) a holding device which secures said workpiece in said oriented position relative to said ejector device while said workpiece surface is etched;

c) a delivery system which delivers said machining etchant fluid to said at least one ejector device.

29. The apparatus of Claim 28, wherein said at least one ejector device is an array of ejector devices.

30. The apparatus of Claim 29, wherein said ejector device comprises a spray nozzle.

31. The apparatus of Claim 28, wherein said ejector devices comprise at least one dual nozzle, in which a central orifice for discharge of machining etchant is surrounded by an outer, annular orifice through which machining etchant is also discharged.

32. The apparatus of Claim 31,wherein a selection of pressures and viscosities of a first machining etchant supplied to the central orifice and a second machining

etchant supplied to the annular orifice of said at least one dual nozzle, results in distinct inner and outer jets, whereby the outer jet confines the inner jet to a narrower dimension than would occur in the absence of the outer jet.

33. The apparatus of Claim 27, wherein said holding device comprises a rotating mechanism whereby said workpiece is rotated during said jet etching.

34. The apparatus of Claim 27, wherein said holding device comprises a moving mechanism whereby said workpiece is translated and/or rastered with respect to the ejector device during said jet etching. .

35. The apparatus of Claim 27, wherein said delivery system comprises an injector bar along which an array of nozzles is disposed.

36. The apparatus of Claim 27, including a system which captures effluent machining etchant fluid and returns said etchant fluid for reuse.

37. The apparatus of Claim 30, wherein said delivery system comprises at least two separate pumps, for delivering machining etchant fluid separately to the central orifice and the annular orifice of the at least one dual nozzle.

38. The apparatus of Claim 27, in which the delivery system includes provisions for delivery of the machining etchant fluid in pulsed fashion, rather than continuous flow.